

WATERPROOF ELECTRICAL CONNECTOR

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] This invention relates to a waterproof electrical connector, specifically, a waterproof electrical connector in which misalignment between thru-holes formed in a flexible plug and wire terminal chambers, or between thru-holes formed in a flexible plug and thru-holes formed in an inner housing can be prevented even though a compressive force distorts the flexible plug.

2. Description of Related Art

[0002] A conventional waterproof electrical connector typically employs a single-piece flexible sealing component as means of waterproofing multiple wire passages in the connector (see Japanese Laid-Open Patent No. 2002-124336). As shown in Figure 20A, waterproof connector 1 has base housing 2 which includes multiple terminal chambers 2a, and perimeter wall 2b that encloses internal space 2c, perimeter wall 2b being located at the rear surface of base housing 2. Flexible plug 3 includes flexible ribs 3a formed at the external surface thereon, and installed within internal space 2c with flexible ribs 3a being compressed against the inner surfaces of the walls that define internal space 2c. Flexible plug 3 includes thru-holes 3b that corresponds to the positions of terminal chambers 2a. Wire terminal T, which is attached to the end of each wire passing through each thru-hole 3b, is inserted into each terminal chamber 2a. Wires W are waterproofed by means of the inner surfaces of each thru-hole 3b in flexible plug 3 maintaining flexible pressurized contact with the external surface of each wire W. Rear cover 4 is installed at the rearward end of perimeter wall 2b to secure flexible plug 3 within internal space 2c.

[0003] The above-noted prior art structure exhibits a specific shortcoming. As illustrated in Figure 20B, flexible plug 3 is subject to constrictive pressure applied by the internal surfaces of the wall that defines internal space 2c in the connector housing when flexible plug 3 is inserted therein. This constrictive pressure has the effect of positionally

displacing thru-holes 3b toward the center of the connector, a phenomenon which is especially pronounced for the thru-holes located closest to the perimeter of flexible plug 3. As a result, thru-holes 3b do not align accurately with terminal chambers 2a. When this misalignment is present, the insertion of a wire terminal T into a terminal chamber 2a, via thru-hole 3b, may result in the tip of wire terminal T being damaged through contact with a wall delineating a terminal chamber 2a.

SUMMARY OF THE INVENTION

[0004] The invention, having considered the aforesaid shortcoming, puts forth a structure for a waterproof electrical connector in which the aforesaid misalignment between the flexible plug thru-hole and corresponding terminal chamber is substantially reduced, despite the constrictive pressure applied to the flexible plug when inserted into the connector housing.

[0005] In order to solve the aforesaid shortcoming in the prior art structure, the present invention provides a waterproof electrical connector including a base housing that has a plurality of terminal chambers and an internal space defined by a perimeter wall located behind the plurality of terminal chambers, a rear cover that is configured to engage with the base housing to seal the internal space, a flexible plug that extends from an inner surface of the rear cover, the flexible plug being configured to be inserted into the internal space, and ribs that are formed on an outer peripheral surface of the flexible plug. The rear cover has a plurality of thru-holes, and the flexible plug has a plurality of thru-holes. The rear cover thru-holes and the flexible plug thru-holes are configured to concentrically align with the plurality of terminal chambers. The flexible plug also has a channel formed on an inserting surface of the flexible plug. The channel is located between outermost flexible plug thru-holes and the outer peripheral surface of the flexible plug.

[0006] When the ribs on the flexible plug are compressed within the perimeter wall encompassing the internal space, the channel is able to absorb the compression applied to the circumferential portion of the insertion surface of the flexible plug, thus preventing

positional displacement of the thru-holes within the flexible plug, and thus maintaining straight and concentrically aligned passages between the thru-holes and terminal chambers.

[0007] According to the above-described construction, the channel, which is formed on the insertion surface of the flexible plug, is able to compress through the narrowing of the channel space as a result of the pressure applied when the flexible plug is inserted into the internal space of the base housing. Therefore, the flexible plug thru-holes, which are enclosed by the channel, are substantially unaffected by the radial constriction of the flexible plug, and thus the concentric alignment between the terminal chambers and thru-holes is maintained.

[0008] It is preferable that the channel be formed on the surface of the flexible plug as a continuous loop. Doing so will result in a uniform reduction of pressure at the thru-holes located near the peripheral region of the insertion surface of the flexible plug. Moreover, a continuous loop channel will also prevent variations in the pressure applied against the aforesaid ribs by the inner walls of the internal space.

[0009] According to the another aspect of the present invention, a waterproof electrical connector is provided including a base housing that has a plurality of terminal chambers and an internal space defined by a perimeter wall located behind the plurality of terminal chambers, a rear cover that is configured to engage with the base housing to seal the internal space, a flexible plug that extends from an inner surface of the rear cover, the flexible plug being configured to be inserted into the internal space, and ribs that are formed on an outer peripheral surface of the flexible plug. The rear cover has a plurality of thru-holes, and the flexible plug has a plurality of thru-holes. The rear cover thru-holes and the flexible plug thru-holes are configured to concentrically align with the plurality of terminal chambers. Each outermost thru-hole of the plurality of flexible plug thru-holes is axially curved outward toward an inserting end of the flexible plug.

[0010] When the ribs on the flexible plug are compressed within the perimeter wall defining the internal space, the pressure applied to the outwardly curved outermost thru-

holes results in their inward displacement which straightens and concentrically aligns the thru-holes with each corresponding terminal chamber.

[0011] When the flexible plug is constricted through insertion into the internal space in the base housing, the outermost thru-holes in the flexible plug, as a result of their outwardly curved axis, are displaced into straight and concentric alignment with corresponding terminal chambers, thus providing a mechanism that prevents misalignment between the thru-holes and terminal chambers.

[0012] In another version of the present invention, a waterproof electrical connector is provided in which the rear cover has a plurality of thru-holes, and the flexible plug has a plurality of thru-holes. The rear cover thru-holes and the flexible plug thru-holes are configured to concentrically align with the plurality of terminal chambers. Each outermost thru-hole of the plurality of rear cover thru-holes has a diameter larger than a diameter of interior thru-holes of the plurality of rear cover thru-holes. An inward wall portion of each outermost thru-hole of the plurality of flexible plug is inclined outward toward an inserting end of the flexible plug so that a diameter of the outermost flexible plug thru-hole decreases toward the inserting end, when the flexible plug is separated from the base housing.

[0013] When the ribs on the flexible plug are compressed within the perimeter wall defining the internal space, the constrictive pressure applied to the peripheral edge of the inserting side of the flexible plug deforms the opening part of each thru-hole into concentric alignment with each corresponding terminal chamber, thus providing a mechanism that prevents misalignment between the thru-holes and terminal chambers.

[0014] When the flexible plug is constricted through insertion into the internal space provided in the base housing, the outermost thru-holes, that is, the thru-holes whose inward wall parts incline outwardly, concentrically align with the terminal chambers as a result of the aforesaid constriction, thus providing a mechanism that prevents misalignment between the thru-holes and terminal chambers.

[0015] In still another version of the present invention, a waterproof electrical connector is provided in which the rear cover has a plurality of thru-holes, and the

flexible plug has a plurality of thru-holes. The rear cover thru-holes and the flexible plug thru-holes are configured to concentrically align with the plurality of terminal chambers. An outward wall portion of each outermost thru-hole of the plurality of flexible plug thru-holes is inclined outward from an end connecting to the rear cover to an inserting end so that a diameter of the outermost flexible plug thru-hole increases toward the inserting end, when the flexible plug is separated from the base housing.

[0016] Therefore, when the ribs on the flexible plug are compressed within the perimeter wall defining the internal space, the constrictive pressure applied to the peripheral edge of the inserting side of the flexible plug deforms the opening part of each thru-hole into concentric alignment with each corresponding terminal chamber, thus providing a mechanism that prevents misalignment between the thru-holes and terminal chambers.

[0017] When the flexible plug is constricted through insertion into the internal space in the base housing, the outer wall part of the outermost thru-holes (each outermost thru-hole having an outwardly inclined outward wall part that forms a gradually increasing thru-hole diameter) is pressed inward to a point where the thru-hole substantially concentrically aligns with the terminal chambers, thus providing a mechanism that prevents misalignment between the thru-holes and terminal chambers.

[0018] An inner housing may be provided in the internal space of the base housing, and the inner housing may incorporate thru-holes that concentrically align with the terminal chambers in the base housing and the thru-holes in the flexible plug and rear cover. A connector housing of this type, that is, a connector housing including a separately constructed base housing and inner housing, may be used because of the convenience in molding process, and so on, and allows the wire terminals to be inserted into the terminal chambers in the base housing via the thru-holes in the inner housing. Thus, this type of connector housing concentrically aligns the thru-holes in the inner housing with the terminal chambers as well as the thru-holes in the flexible plug and rear cover, thus allowing the smooth insertion of the wire connector terminals attached to the wire ends.

[0019] A wire terminal, which is attached to a wire end, is inserted through the thru-holes provided in the rear cover, flexible plug, and inner housing. An engaging portion may be provided in at least one thru-hole in the inner housing. The engaging portion may engage with a corresponding engaging portion provided on the wire terminal. Thus, the front portion of the wire terminal securely resides within each terminal chamber.

[0020] By eliminating misalignment between the flexible plug thru-holes and terminal chambers (by the channel, or by axial curve and inclined wall portion of the flexible plug thru-holes, as described above), the above-described flexible plug allows the smooth and unobstructed insertion of the wire terminals into the terminal chambers via the thru-holes in the rear cover, flexible plug, and inner housing. After insertion, the wire connector terminals are securely locked into position by the engaging portion provided in the inner housing.

[0021] In further aspect of the present invention, a waterproof electrical connector is provided including a base housing that has a plurality of terminal chambers and an internal space defined by a perimeter wall located behind the plurality of terminal chambers, an inner housing installed to a floor of the internal space in the base housing, a rear cover configured to engage with the base housing to seal the internal space, a flexible plug extending from an inner surface of the rear cover, the flexible plug being configured to be inserted into the internal space, and ribs formed on an outer peripheral surface of the flexible plug. The rear cover has a plurality of thru-holes, and the flexible plug has a plurality of thru-holes. The rear cover thru-holes and the flexible plug thru-holes are configured to concentrically align with the plurality of terminal chambers. A distortion suppressing flange extends from a perimeter of an inserting surface of the flexible plug, and a ledge is formed in a perimeter wall of the inner housing. The ledge is configured to engage with the distortion suppressing flange.

[0022] The fitting of the distortion suppressing flange over the ledge on the inner housing has the effect of maintaining the flexible plug thru-holes in concentric alignment with the inner housing thru-holes, despite the compression of the ribs of the flexible plug within the perimeter wall that defines the internal space of the base housing.

[0023] According to this construction, when the flexible plug is radially compressed as a result of its insertion into the internal space of the base housing, the attachment of the distortion suppressing flange on the flexible plug to the ledge on the inner housing has the effect of minimizing the distortion of the flexible plug, thus forming a mechanism that prevents the thru-holes in the flexible plug from being displaced out of alignment with the terminal chambers in the base housing.

[0024] The inner housing may be previously (firstly) installed within the internal space of the base housing. Doing so will axially align the thru-holes in the inner housing with the terminal chambers and thru-holes in the flexible plug and rear cover, thus allowing the smooth and unobstructed insertion of the connector terminals into the terminal chambers.

[0025] Alternatively, the inner housing may be previously attached to the inserting side of the flexible plug, and installed into the internal space in the base housing together with the flexible plug. Because the distortion suppressing flange on the flexible plug is already attached to the ledge on the inner housing, the flexible plug can be easily inserted into the base housing, without distortion, even though a load is applied to the perimeter of the inserting side of the flexible plug.

[0026] It is preferable that the distortion suppressing flange be formed as a continuous loop that extends from the perimeter of the inserting surface of the flexible plug, and that the aforesaid ledge be formed as a continuous loop on an end of the inner housing. This type of structure uniformly reduces the pressure applied to the thru-holes in proximity to the perimeter at the inserting side of the flexible plug. In addition, variations of compressive forces on the ribs, which are pressed by the interior surface of the internal space can be prevented.

[0027] Moreover, it is preferable that the flexible plug and rear cover be formed as a single piece by double-molding, in which the flexible plug is made from a resilient elastomer, and the rear cover from a hard synthetic resin (hereinafter, referred to as hard resin).

[0028] Such a structure, in which the flexible plug is formed as an integral component of the rear cover, provides for easier and more efficient assembly of the electrical connector, and prevents misalignment between the thru-holes in the flexible plug and rear cover when the base part of the flexible plug is constricted as a result of its insertion into the internal space provided in the base housing. This structure is thus able to maintain an accurately aligned insertion path, extending from the first insertion point at the rear cover to the terminal chamber, through which the wire terminal can be inserted.

[0029] Alternatively, the flexible plug, which extends from the internal surface of the rear cover, may be formed as a separate component from the rear cover, and then attached to the rear cover through an interlocking joint, instead of double-molding.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030] The present invention is further described in the detailed description which follows, with reference to the noted plurality of drawings by way of non-limiting examples of exemplary embodiments of the present invention, in which like reference numerals represent similar parts throughout the several views of the drawings, and wherein:

Figure 1 is an exploded cross sectional view of a waterproof electrical connector according to the first embodiment of the present invention.

Figure 2A is a front view of a flexible plug and a rear cover integrated as a single component according to the first embodiment.

Figure 2B is a cross section of Figure 2A taken along the line X-X in Figure 2A.

Figure 3 is a cross section of an assembled connector including the base housing, inner housing, and flexible plug/rear holder, according to the first embodiment.

Figure 4A is a detailed cross section showing the flexible plug partially inserted into the internal space in the base housing, according to the first embodiment.

Figure 4B is the same detailed cross section with the flexible plug fully inserted.

Figure 5 is a cross section of the electrical connector showing wire connector terminals inserted into the terminal chambers, according to the first embodiment.

Figure 6 is an exploded cross sectional view of a waterproof electrical connector according to the second embodiment of the present invention.

Figure 7A is a plan view of the flexible plug and rear cover according to the second embodiment.

Figure 7B is a cross section taken along the line X-X in Figure 7A.

Figure 8 is a cross section of an assembled electrical connector including the base housing, inner housing, flexible plug, and rear cover, according to the second embodiment.

Figure 9A is a cross section of the flexible plug of the second embodiment partially inserted in the internal space in the base housing.

Figure 9B is illustrates the flexible plug of the second embodiment in a completely inserted condition.

Figure 10 is a cross section of the wire terminals completely inserted in the terminal chambers, according to the second embodiment.

Figure 11A is a frontal view of the flexible plug and rear cover of the third embodiment.

Figure 11B is a side cross section of the Figure 11A view taken along the line X-X.

Figure 12A is a side view cross section of the third embodiment showing the flexible plug partially inserted into the internal space in the base housing.

Figure 12B is a side view cross section of the third embodiment showing the wire terminals inserted in the terminal chambers.

Figure 13A is a frontal view of the flexible plug and rear cover of the fourth embodiment.

Figure 13B is a side cross section of the Figure 13A view taken along the line X-X.

Figure 14A is a side view a partial cross section of the fourth embodiment showing the flexible plug partially inserted into the internal space in the base housing.

Figure 14B is a side view cross section of the fourth embodiment showing the flexible plug the wire terminals inserted in the terminal chambers.

Figure 15 is an exploded cross section of a waterproof electrical connector according to the fifth embodiment of the present invention.

Figure 16A is a plan view of the flexible plug and rear cover, according to the fifth embodiment.

Figure 16B is a cross section taken along the line X-X in Figure 16A.

Figure 17 is a cross section of an assembled electrical connector including the base housing, inner housing, flexible plug, and rear cover, according to the fifth embodiment.

Figure 18A is a cross section of the flexible plug partially inserted in the base housing internal space, according to the fifth embodiment.

Figure 18B illustrates the flexible plug of the fifth embodiment in a completely inserted condition.

Figure 19 is a cross section of the wire terminals completely inserted in the terminal chambers, according to the fifth embodiment.

Figure 20A is a cross section of a conventional waterproof electrical connector.

Figure 20B is a detailed cross section of the part of the conventional waterproof electrical connector showing the shortcoming thereof.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0031] The following will describe embodiments of the present invention with reference to the attached drawings.

[0032] Figures 1 through 5 illustrate a first embodiment of the present invention. As shown in Figure 1, waterproof electrical connector 10 includes two-piece housing 11 which has base housing 12 and inner housing 13, both being made of any suitable material, for example, a synthetic resin. Connector 10 also includes flexible plug 14 through which all of multiple wires W pass, rear cover 15 which attaches to the rear side of base housing 12, and wire terminals T which are attached to the ends of wires W and which reside within base housing 12.

[0033] Multiple rows of terminal chambers 12a (arranged in a matrix) are formed within base housing 12 and pass completely therethrough. Insertion orifices 12b, which

are located at the front face of the connector, provide spaces through which male wire terminals (not shown in the drawings) of an opposite connector, that connect to wire terminals T, may be inserted. Internal space 12d, which serves as a repository for inner housing 13 and flexible plug 14, is defined by perimeter wall 12c located at the rearward side of base housing 12, and connects to the rear part of multiple terminal chambers 12a that are formed within base housing 12.

[0034] Inner housing 13 is installed to the innermost part of internal space 12d, and thus leaves space for the installation of flexible plug 14 in the remaining rear portion therein. Thru-holes 13a are formed in inner housing 13 so that each thru-hole 13a is concentrically aligned with each terminal chamber 12a in base housing 12. Lock tab 13b protrudes from an internal surface of each thru-hole 13a to engage with stop edge Ta of wire terminal T to secure the position of each wire terminal T within the connector. In this embodiment, as shown in Figure 5, lock tab 13b is a cantilevered member that extends into the entrance of terminal chamber 12a in the direction in which wire terminal T is inserted. The rearward extremity of wire terminal T forms a jaw that serves as stop edge Ta, and thus the removal of wire terminal T is prevented by a latch-like mechanism. However, the structure of the engagement between the terminal T and the inner housing 13 is not limited to this embodiment, as long as a structure is provided that can securely hold wire terminal T within base housing 12. For example, a protruding member and a hole engaging therewith, or a projection and a recess engaging with each other can also be used. In addition, the latch engagement structure can be provided in less than all thru-holes of the inner housing, and/or wire terminals.

[0035] As shown in Figures 2A and 2B, flexible plug 14 is a square, brick-shaped component made from any suitable material, such as a flexible elastomer and shaped to an external contour that corresponds to that of internal space 12d. Multiple ribs 14a extend from the perimeter surface of flexible plug 14 and, as shown in Figure 3, press against the internal surface of perimeter wall 12c when flexible plug 14 is installed to internal space 12d. Moreover, multiple thru-holes 14b, which run completely through flexible plug 14, are located in concentric alignment with each terminal chamber 12a and

thru-hole 13a in inner housing 13. The internal surface of each of thru-holes 14b is formed to a wave-like contour in the axial direction to a dimension that allows flexible plug 14 to elastically grip the external surface of each wire W in each thru-hole 14b.

[0036] Moreover, channel 14c, which is cut into the surface of the inserting side of flexible plug 14 in the rearward direction, is located between outermost thru-holes 14b and the external surface of flexible plug 14. Channel 14c is approximately V-shaped in cross section with the narrow end of the V-shape extending into flexible plug 14. Viewed from the inserting surface of flexible plug 14, channel 14c encompasses outermost thru-holes 14b, and provides a continuous space that separates thru-holes 14b from the external surface on which ribs 14a are formed. As a result, when ribs 14a are compressed in the radial direction, channel 14c absorbs the compression applied through ribs 14a.

[0037] As shown in Figures 1 and 2A/B, rear cover 15, which is a cap-shaped component usually made from the same synthetic resin as base housing 12, but which may be made from any suitable material, attaches to the rearward surface of perimeter wall 12c to seal internal space 12d of base housing 12. Latch mechanism 16, as shown in Figure 3, is formed on sidewall 15a of rear cover 15 and on perimeter wall 12c of base housing 12, thus securing rear cover 15 to perimeter wall 12c. Moreover, thru-holes 15c are formed within base plate 15b of rear cover 15, to allow the insertion of wire terminals T therein, each thru-hole 15c being concentrically aligned to a corresponding thru-hole 14b in flexible plug 14.

[0038] In this embodiment, flexible plug 14, made from a resilient (soft) elastomer, and rigid resin rear cover 15 are combined by double-molding to form a single component exhibiting two different material properties, and incorporating thru-holes 14b and 15c in mutual concentric alignment. This type of structure, in which the rear surface of flexible plug 14 is securely attached to the internal side of base plate 15b of rear cover 15, prevents a change in spacing between thru-holes 14b or misalignment between the thru-holes 14b and thru-holes 15c when ribs 14a are radially compressed as a result of flexible plug 14 being inserted into internal space 12d.

[0039] Furthermore, as shown in Figure 5, connector cover 17 may be attached to base housing 12 to support each wire W whose wire terminal T resides in terminal chamber 12a and whose opposite end passes through rear cover 15 to the external environment. Connector cover 17 may also be employed to guide each wire W out of connector 10 in the sideward direction.

[0040] The following will explain the operation and effects of waterproof connector 10 according to the first embodiment.

As shown in Figure 3, inner housing 13 is inserted into internal space 12d in base housing 12, thereby concentrically aligning each thru-hole 13a with a corresponding terminal chamber 12a. Flexible plug 14, which is integrated with a rear cover 15 as one-piece is then inserted into internal space 12d, thus resulting in ribs 14a on the perimeter surface being compressed against perimeter wall 12c to form a waterproof seal therebetween. The position of thru-holes 14b located near the perimeter of flexible plug 14 (in particular, the outermost thru-holes 14b) will normally change as a result of the inward compression of ribs 14a from contact with the internal surface of perimeter wall 12c. However, as shown in Figures 4A and 4B, channel 14c, which is provided on the surface of the inserting side of flexible plug 14, is able to absorb the compression of ribs 14a through the narrowing of the channel space. This mechanism results in the constrictive pressure applied to flexible plug 14 having relatively little effect on the position of thru-holes 14b located near the perimeter, and therefore the positional displacement of thru-holes 14b can be prevented.

[0041] The base plate side positional displacement of thru-holes 14b, which normally results from the constrictive pressure applied to ribs 14a, can also be prevented because the bottom surface of flexible plug 14 is securely attached to rear cover 15 so as to create a single component including both flexible plug 14 and rear cover 15. Therefore, the complete insertion of flexible plug 14 into internal space 12d results in the simultaneous attachment of perimeter wall 15a of rear cover 15 to perimeter wall 12c, the engagement of latch mechanism 16, and the concentric alignment of thru-holes 15c, 14b, and 13a that

form multiple straight passages (extending from rear cover 15 through each terminal chamber 12a) for the insertion of each wire terminal T.

[0042] Next, as shown in Figure 5, wire terminal T (which is attached to the end of wire W) is inserted into thru-hole 15c in rear cover 15. Continued insertion results in wire terminal T pushing open thru-hole 14b in flexible plug 14, passing through thru-hole 13a in inner housing 13, and entering terminal chamber 12a. Thus, wire terminal T is able to enter terminal chamber 12a smoothly and easily because the path leading to terminal chamber 12a is axially straight due to the concentric alignment maintained between thru-holes 13a, 14b, and 15c. Once wire terminal T is completely inserted to terminal chamber 12a, lock tab 13b on inner housing 13 engages with stop edge Ta on wire terminal T to secure wire terminal T within terminal chamber 12a. At the same time, the constrictive pressure applied to wire W by the wall of thru-hole 14b forms a waterproof seal therebetween.

[0043] Furthermore, if necessary, connector cover 17 may be installed to the rear of connector 10 to protect wires W that extend from base housing 12, and to guide wires W in a sideward direction out of connector 10.

[0044] Moreover, while the first embodiment has described channel 14c as a continuous loop formed on the surface of the inserting side of flexible plug 14, channel 14c may also be formed intermittently on the surface.

[0045] Figure 6 through 10 illustrate a second embodiment of the present invention. Description will have been omitted for the components of this second embodiment that share identical reference numerals with those of the first embodiment.

[0046] In this embodiment, the axis of each outermost thru-hole 14B in flexible plug 14 curves outward toward an edge of the inserting side of flexible plug 14. The curve is established to an extent that allows thru-holes 14B to straighten, that is, the curved part of each thru-hole will be eliminated, when flexible plug 14 is inserted into internal space 12d and ribs 14a are pressed inward through the pressure applied by perimeter wall 12c. With flexible plug 14 is fully inserted into internal space 12d, outermost thru-holes 14B will have been pressed inward to the point where they straighten and concentrically align

with thru-holes 13a and terminal chambers 12a. Moreover, because the rear surface of flexible plug 14 is joined to the inner surface of base plate 15b of rear cover 15, the alignment of outermost thru-holes 14B with thru-holes 15c on rear cover 15 is maintained even though ribs 14a have been compressed by the insertion of flexible plug 14 into internal space 12d. Therefore, only the portion of thru-holes 14b at the inserting side of flexible plug 14 is curved.

[0047] The following will explain the operation and effects of the second embodiment of the present invention in the form of waterproof connector 10. As shown in Figure 8, inner housing 13 is inserted into internal space 12d in base housing 12, thereby concentrically aligning each thru-hole 13a with a corresponding terminal chamber 12a. Flexible plug 14, which is integrated with rear cover 15 as one-piece, is then inserted into internal space 12d, thus resulting in ribs 14a on the perimeter surface being compressed against perimeter wall 12c to form a waterproof seal therebetween. The position of outermost thru-holes 14B would normally change as a result of the inward compression of ribs 14a resulting from contact with the internal surface of perimeter wall 12c. However, because outermost thru-holes 14B curve outwardly toward the edges of the inserting side of flexible plug 14 to compensate for compression-induced displacement, thru-holes 14B are displaced along a straight axis as illustrated in Figures 9A and 9B. As a result, each inner thru-hole 14b and each outermost thru-hole 14B are maintained in concentric alignment with each corresponding terminal chamber 12a.

[0048] The base plate side positional displacement of outermost thru-holes 14B, which would normally result from the constrictive pressure applied to ribs 14a, can be prevented because the bottom surface of flexible plug 14 is securely attached to rear cover 15 so as to create a single component including both flexible plug 14 and rear cover 15. Therefore, the complete insertion of flexible plug 14 into internal space 12d results in the simultaneous attachment of rear cover 15 to perimeter wall 12c, the engagement of latch mechanism 16, and the concentric alignment of thru-holes 15c, 14b, (14B), and 13a that form multiple concentrically aligned passages (extending from rear cover 15 through each terminal chamber 12a) for the insertion of each wire connector terminal T.

[0049] Next, as shown in Figure 10, wire terminal T (which is attached to the end of wire W) is inserted into thru-hole 15c in rear cover 15. Continued insertion results in wire terminal T pushing open thru-hole 14b in flexible plug 14, passing through thru-hole 13a in inner housing 13, and entering terminal chamber 12a. Wire terminal T is able to enter terminal chamber 12a smoothly and easily because the passage leading to terminal chamber 12a is completely straight due to the concentric alignment maintained between thru-holes 13a, 14b, and 15c. Once wire terminal T is completely inserted to terminal chamber 12a, lock tab 13b on inner housing 13 engages with stop edge Ta on wire terminal T to secure wire terminal T within terminal chamber 12a. At the same time, the constrictive pressure applied to wire W by the wall of thru-hole 14b forms a waterproof seal therebetween.

[0050] Furthermore, if necessary, connector cover 17 may be installed to the rear portion of connector 10 to protect wires W that extend from base housing 12, and of guiding wires W in a sideward direction out of connector 10.

[0051] Figures 11A through 12B illustrate a third embodiment of the invention in the form of waterproof electrical connector 20. In this third embodiment, outermost thru-holes 25C in rear cover 25 are formed to a diameter larger than that of the other thru-holes 25c. Also, outermost thru-holes 24B in flexible plug 24 are formed to a diameter larger than that of the other thru-holes 24b at the part of flexible plug 14 attached to base plate 25b of rear cover 25. Furthermore, the inward wall part of each outermost thru-hole 24B inclines outward as it approaches the inserting side of flexible plug 24, and the outward wall part of each outermost thru-hole 24B does not incline. Thus, the diameter of each thru-hole 24B decreases as the thru-hole approaches the inserting side of flexible plug 14. Descriptions have been omitted for the components of this third embodiment that share identical identification numbers with those of the first embodiment.

[0052] In this third embodiment, the degree of the outward inclination of the inner wall part of each thru-hole 24B is determined so that, when flexible plug 24 is inserted into internal space 12d and compressed by the inner surface of the perimeter wall 12c through

the pressure applied to ribs 14a, a generally continuing path is formed without misalignment by the inward deformation of the inner wall part by the applied pressure.

[0053] The following will explain the operation and effects of the third embodiment.

Similar to the first or second embodiment, inner housing 13, flexible plug 24, and rear cover 25 are installed to base housing 12. As illustrated in Figure 12A and 12B, ribs 14a of flexible plug 24 are inwardly displaced at the inserting side of flexible plug 24 as a result of pressure applied by perimeter wall 12c of internal space 12d. While each outermost thru-hole 24B is initially formed with the inward wall part inclined outward, the constrictive pressure applied to flexible plug 24 has the effect of displacing the opening to each thru-hole 24B into alignment with each corresponding terminal chamber 12a.

[0054] With flexible plug 24 thus installed, wire terminals T, which are attached to electrical wires W, can be inserted through thru-holes 25c (25C) of rear cover 25 in the same manner as described for the first or second embodiment. During the insertion process, wire terminal T forcefully expands thru-hole 24b (24B), passes through thru-hole 13a in inner housing 13, and enters terminal chamber 12a. Once wire terminal T is fully inserted, lock tab 13b on inner housing 13 engages stop with edge Ta to anchor wire terminal T in position. Wire W is elastically gripped in the radial direction by thru-hole 24b to form a watertight seal therebetween.

[0055] Furthermore, connector cover 17 may be installed to the rear of the connector to protect wires W that extend from base housing 12, and to guide wires W in a sideward direction out of the connector.

[0056] Figures 13A through 14B describe a fourth embodiment of the present invention wherein each outermost thru-hole 34B (among thru-holes 34b in flexible plug 34) is formed to an increasingly larger diameter as the thru-hole approaches the inserting side of flexible plug 34. More specifically, the outward wall part of each thru-hole inclines outwardly from its contact surface with base plate 35b to the inserting side of flexible plug 34. The opposing inner wall part does not incline, and thru-hole 34B is formed with a diameter that continuously increases as the thru-hole approaches the inserting side of

flexible plug 34. Descriptions have been omitted for components of this fourth embodiment that share identical identification numbers with those of the first embodiment.

[0057] In this fourth embodiment, the degree of the outward inclination of the outer wall part of each thru-hole 34B is determined so that, when flexible plug 34 is inserted into internal space 12d and compressed by the inner surface of the perimeter wall 12c through the pressure applied to ribs 14a, a generally continuing path is formed without misalignment by the inward deformation of the outer wall part by the applied pressure.

[0058] The following will explain the operation and effects of the fourth embodiment.

Similar to the first through third embodiments, inner housing 13, flexible plug 34, and rear cover 35 are installed to base housing 12. Ribs 14a of flexible plug 34 are compressed inward at the inserting side of flexible plug 34 as a result of pressure applied by perimeter wall 12c of internal space 12d. While each outermost thru-hole 34B is initially formed with the outward wall part inclined in the outward direction to increase the diameter of the thru-hole 34B, the constrictive pressure applied to flexible plug 34 displaces each thru-hole 34B into alignment with each corresponding terminal chamber 12a.

[0059] With flexible plug 34 installed, wire terminals T, which are attached to electrical wires W, can be inserted through thru-holes 35c of rear cover 35 in the same manner as described for the first through third embodiments. During insertion, wire terminal T forcefully expands thru-hole 34b (34B) of flexible plug 34, passes through thru-hole 13a in inner housing 13, and enters terminal chamber 12a. Once wire terminal T is fully inserted, lock tab 13b on inner housing 13 engages with stop edge Ta to anchor wire terminal T in position. Wire W elastically gripped in the radial direction by thru-hole 34b (34B) to form a watertight seal therebetween.

[0060] Furthermore, connector cover 17 may be installed to the rear of the connector to protect wires W that extend from base housing 12, and to guide wires W in a sideward direction out of the connector.

[0061] In the above-described embodiments, housing 11 is a 2-piece structure including base housing 12 and inner housing 13. Housing 11, however, may also be formed as a single piece structure that integrates base housing 12 and inner housing 13.

[0062] Figure 15 through 19 illustrate a fifth embodiment of the present invention. Description will have been omitted for the components of this fifth embodiment that share identical reference numerals with those of the first embodiment.

[0063] In this embodiment, a loop-like ledge 13c is provided along the entire perimeter of a rear surface on the inner housing 13. The ledge 13c engages with a distortion suppressing flange 14d extending from an inserting surface of the flexible plug 14.

[0064] Distortion suppressing flange 14d (hereafter referred to as flange 14d) extends outward in the insertion direction from the perimeter of the insertion surface of flexible plug 14. Flange 14d fits over ledge 13c, which is formed as an indented shelf-type structure extending outward from the perimeter of the rearward part of inner housing 13. Inner surface of flange 14d is radially pressurized in the outward direction through attachment to ledge 13c, thus creating a structure able to prevent distortion at the perimeter of the insertion side of flexible plug 14 when ribs 14a are constricted within internal space 12d.

[0065] The following will explain the operation and effects of the fifth embodiment of the present invention in the form of waterproof connector 10.

[0066] As shown in Figure 17, flange 14d fits over ledge 13c on inner housing 13, thereby concentrically aligning each thru-hole 14b with a corresponding thru-hole 13a. Rear cover 15, which is a single one-piece structure that includes flexible plug 14, is then inserted into internal space 12d, thus resulting in ribs 14a being compressed within perimeter wall 12c to form a waterproof seal therebetween. The position of thru-holes 14b, especially those located near the perimeter of flexible plug, would normally change as a result of the inward compression of ribs 14a caused by pressurized contact with the internal surface of perimeter wall 12c. However, because flange 14d fits over ledge 13c of inner housing 13 with the inner surface of flange 14d pressed outward, as shown in Figures 18A and 18B, there is no positional displacement at the insertion end of flexible

plug 14 even though ribs 14a have been constricted. This structure thus substantially reduces the amount of compression applied to thru-holes 14b near the perimeter of flexible plug 14 and prevents misalignment.

[0067] Because flexible plug 14 and rear cover 15 are joined at the base part of rear cover 15 to form a single integrated component, the part of thru-holes 14b at the base of flexible plug 14 is substantially unaffected by the compression of ribs 14a. The complete insertion of flexible plug 14 into internal space 12d results in the simultaneous attachment of sidewall 15a of rear cover 15 to perimeter wall 12c, and the engagement of latch mechanism 16. This results in the straight and concentric alignment of thru-holes 15c, 14b, and 13a from rear cover 15 to terminal chambers 12a, and thus forms straightly aligned passages through which wire terminals T may be inserted.

[0068] Next, as shown in Figure 19, wire terminal T (which is attached to the end of wire W) is inserted into thru-hole 15c in rear cover 15. Continued insertion results in wire terminal T pushing open thru-hole 14b in flexible plug 14, passing through thru-hole 13a in inner housing 13, and entering terminal chamber 12a. Wire terminal T is able to enter terminal chamber 12a smoothly without obstruction because the passage leading to terminal chamber 12a is straight due to the concentric alignment maintained between thru-holes 13a, 14b, and 15c. Once wire terminal T is completely inserted to terminal chamber 12a, lock tab 13b on inner housing 13 engages with stop edge Ta on wire terminal T to secure wire terminal T within terminal chamber 12a. At the same time, the constrictive pressure applied to wire W by the wall of thru-hole 14b forms a waterproof seal therebetween.

[0069] While this fifth embodiment describes inner housing 13 and flexible plug 14 being initially assembled and then inserted into internal space 12d of base housing 12, inner housing 13 may first be inserted into internal space 12d, and then flexible plug 14 may be joined to inner housing 13.

[0070] While all of the embodiments have described flexible plug 14 (24, 34) and rear cover 15 (25, 35) as double-molded to form an integrated structure exhibiting two different material properties, flexible plug 14 (24, 34) and rear cover 15 (25, 35) may be

initially formed as separate components that are then mutually joined by using an adhesive or latch engagement. In addition, while the embodiments describe wire terminal T as a female-type connector terminal, wire terminal T may also be structured as a male-type wire terminal.

[0071] As described in the above explanation, the waterproof electrical connector according to the present invention incorporates a continuous channel formed into the insertion face of the flexible plug and located between the outermost thru-holes and the perimeter surface of the flexible plug. According to this structure, the channel is able to absorb the compression generated on the outer circumferential part of the flexible plug when the flexible plug is inserted into the internal space within the base housing.

[0072] The waterproof electrical connector according to the present invention further provides a structure in which the outwardly curved axes of the outermost thru-holes in the flexible plug, or the inclined wall parts of the thru-holes, are able to absorb pressure applied to the perimeter of the flexible plug when the flexible plug is inserted into the inner space of the base housing, because those inclined axes or the inclined wall parts are designed based on the prediction of displacement of those outermost thru-holes.

[0073] The waterproof electrical connector according to the present invention further incorporates a distortion suppressing flange extending from the perimeter of the inserting side of the flexible plug in the inserting direction. The inner surface of the distortion suppressing flange fits over a ledge formed around the perimeter of an end of the inner housing, thus preventing the distortion of the flexible plug when the perimeter of the flexible plug is constricted through its insertion into the internal space in the base housing.

[0074] As a result, the positional displacement of the thru-holes within the flexible plug is prevented, thus allowing the wire connector terminals on the wire ends to be easily and smoothly inserted through the flexible plug and into the terminal chambers.

[0075] It is noted that the foregoing examples have been provided merely for the purpose of explanation and are in no way to be construed as limiting of the present invention. While the present invention has been described with reference to exemplary embodiments, it is understood that the words which have been used herein are words of

description and illustration, rather than words of limitation. Changes may be made, within the purview of the appended claims, as presently stated and as amended, without departing from the scope and spirit of the present invention in its aspects. Although the present invention has been described herein with reference to particular structures, materials and embodiments, the present invention is not intended to be limited to the particulars disclosed herein; rather, the present invention extends to all functionally equivalent structures, methods and uses, such as are within the scope of the appended claims.

[0076] The present invention is not limited to the above described embodiments, and various variations and modifications may be possible without departing from the scope of the present invention.

[0077] This application is based on the Japanese Patent Applications No. 2002-323400 and 2002-324314, both filed on November 7, 2002, Japanese Patent Application No. 2002-325202 filed on November 8, 2002, the entire contents of which is expressly incorporated by reference herein.